26/04/2022



### GRPE Informal Working Group on EVE Battery durability in e-buses, view from bus operators Tanguy Bouton, Transdev Group

26/04/2022



### SUMMARY

- Introduction: Transdev Group Zero Emission Experience
- Key Figures of Transdev "Average" E-buses
- A Fundamental Parameter of Batteries: the C-Rate
- Battery Degradation Over Time
- Battery Procurement & Warranty Conditions

# SPEAKER – TANGUY BOUTON

- 2013 PVI
  - 。 Electric Vehicle Project Manager
- 2015 RATP Dev Dubai
  - Urban Planner
- 2016 Transdev France
  - Energy Transition Business Manager
- 2018 Transdev Corporate
  - Energy Transformation Business Manager
- 2019 Transdev Corporate
  Croup Elect Director
  - Group Fleet Director
- 2019 Transdev Corporate
  - 。 ZE Team Program Manager







## **INTRODUCTION: TRANSDEV GROUP ZERO EMISSION EXPERIENCE**

#### ZE bus fleet current and prospective evolution<sup>1</sup>



2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

- 1,800 vehicles are now being operated within the Group
- Transdev has just hit the target of "1,500 e-buses by 2024" ahead of time
- Acceleration is ongoing with higher demand for complete transformation
- The pace could increase even more given stimulus packages and new regulations
- To be noted: very country-specific due to different energy mix orientations

<sup>1</sup> Data is based on existing contracts, vehicle orders and ongoing deliveries to date <sup>2</sup> Source: Accuracy analysis, March 2019

<sup>3</sup>25 KingLong already in operation. 233 Foton e-buses will be added in the 2nd semester of 2022. <sup>4</sup>43 units as oftoday. More VDL e-buses will be inservice in November 2022

#### Top 5 largest operations worldwide



VDL



### **KEY FIGURES OF TRANSDEV "AVERAGE" E-BUSES**

	Standard bus (12m)	Articulated bus (18m)
Maker & Model	Heuliez GX 337 ELEC / E-WAY 12m	VDL Citea SLFA-180
Weight (in operation)	19,500 kg	29,000 kg
Nominal battery capacity	350 kWh	180 kWh
Average mileage	220 km/day	300 km/day
Charging operations	1/day	4/day
Charging type	Overnight Plug (CCS Type 2)	Opportunity Pantograph Up (OppCharge)
Charging power	50 kW	300 kW 30 kW











## A FUNDAMENTAL PARAMETER OF BATTERIES: THE C-RATE

- Charge and discharge speed of a battery are indicated by the Factor C or C-rate, calculated as the charging or discharging power divided by capacity, or how long in hours (theoretically) to charge the battery from 0% to 100%
- For a **100 kWh battery**:
  - 0.5 C = charging a battery pack in 2 hours with 50kW
  - 1 C = charging a battery pack in 1 hour with 100 kW
  - 3 C = charging a battery pack in 20 min with 300 kW
- High-performance batteries can be charged above 1C
- Slow charging Example : 280 kWh to be charged with a 80 kW charger
  - $\circ$  Charging time 280/80 = 3.5 hours
  - $\circ$  C-rate = 80/280 = 0.29 C







# **BATTERY DEGRADATION OVER TIME**

Storage

#### Battery ageing/fading

- Side reactions between electrode, electrolyte and current collectors
  - Loss of capacity
  - Impedance rise
- **Battery ageing type** 
  - Calendar ageing (I=0)
  - Cycling ageing  $(I \neq 0)$

#### Calendar ageing mechanism

- Formation and growth of the SEI (solid electrolyte interface) layer on the negative (graphite) electrode.
- The main factors accelerating this mechanism are temperature and SoC

#### Cycling ageing mechanism

- The lithium plating of the negative electrode
- This mechanism is amplified with colder temperatures and higher C-rates
- EV batteries typically reach end of (first) life, EOL, at 80% of initial capacity
  - Thereafter, capacity reduces faster and less predictably
  - Difficult to employ 2<sup>nd</sup> life battery in fleet, more useful in stationary applications





Number of cycles





### Four factors affecting battery life (theoretical data)

the mobility compan





### **BATTERY PROCUREMENT & WARRANTY CONDITIONS**

### Battery warranty and specification format used in request for proposal









### Example of completed template











# **QUESTIONS?**